Pilot-Scale Development of a UAV-UGV Hybrid system with Air-Based UGV Path Planning

Interactive Robots and Media Lab (IRML)

NEW YORK UNIVERSITY ABU DHABI

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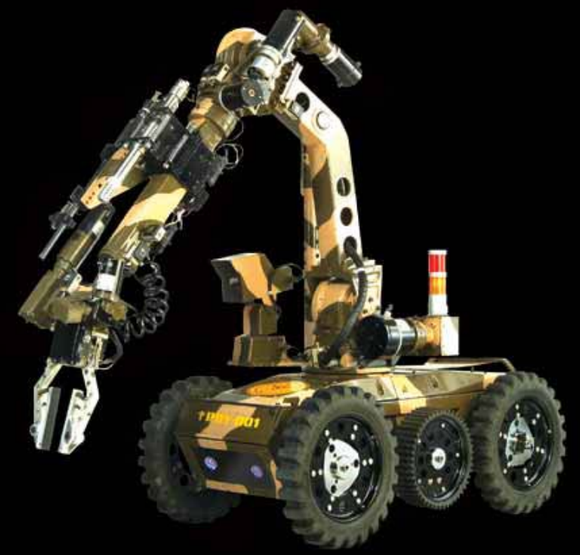
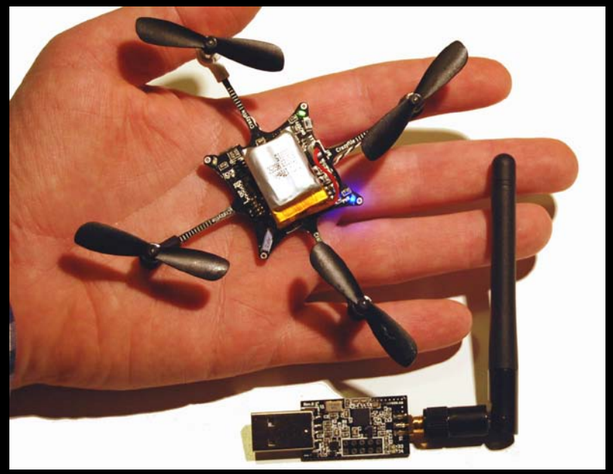
Robots for military use today...

Ground Robots (UGV)



Robots for military use today...

Aerial Robots (UAV)



Robots for military use today...

Ground Robots (UGV)

Advantages

- Able to carry heavy loads
- High endurance
- Able to be equipped with high gain communication modules
- Able to be equipped with heavy sensors and actuators
- etc.

Disadvantages

- Are unwieldy
- Have small field of view
- Can't move autonomously to unknown environments
- Can't move to any terrain
- etc.

Robots for military use today...

Aerial Robots (UAV)

Advantages

- Are agile
- Have large field of view
- Can move autonomously to unknown environments
- Can move to any ground terrain
- Can be undiscoverable
- etc.

Disadvantages

- Unable to carry heavy loads
- Low endurance
- Not able to be equipped with high gain communication modules
- Not able to be equipped with heavy sensors and actuators
- etc.

Proposed system...

Hybrid Symbiotic System

+

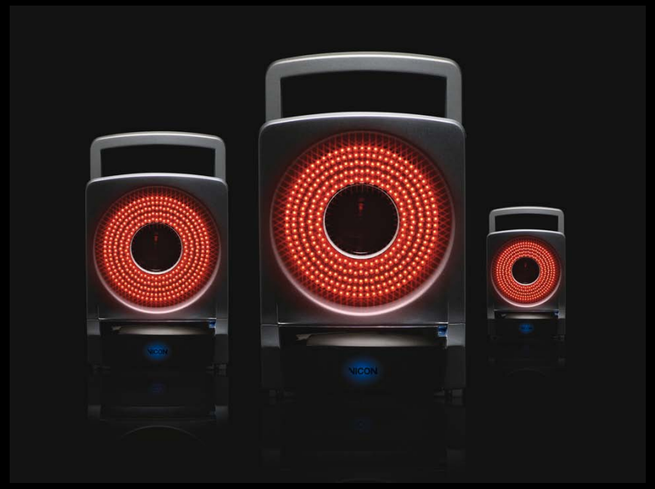
Proposed system...

Essentially, one robotic entity, whose body parts can separate temporarily, and get together again later.

The goal of this project is to navigate a hybrid robot through a simple maze by exploiting the capabilities of its aerial part, in order to create a map of the unknown environment.

Hardware of the system

Vicon Motion Capture system



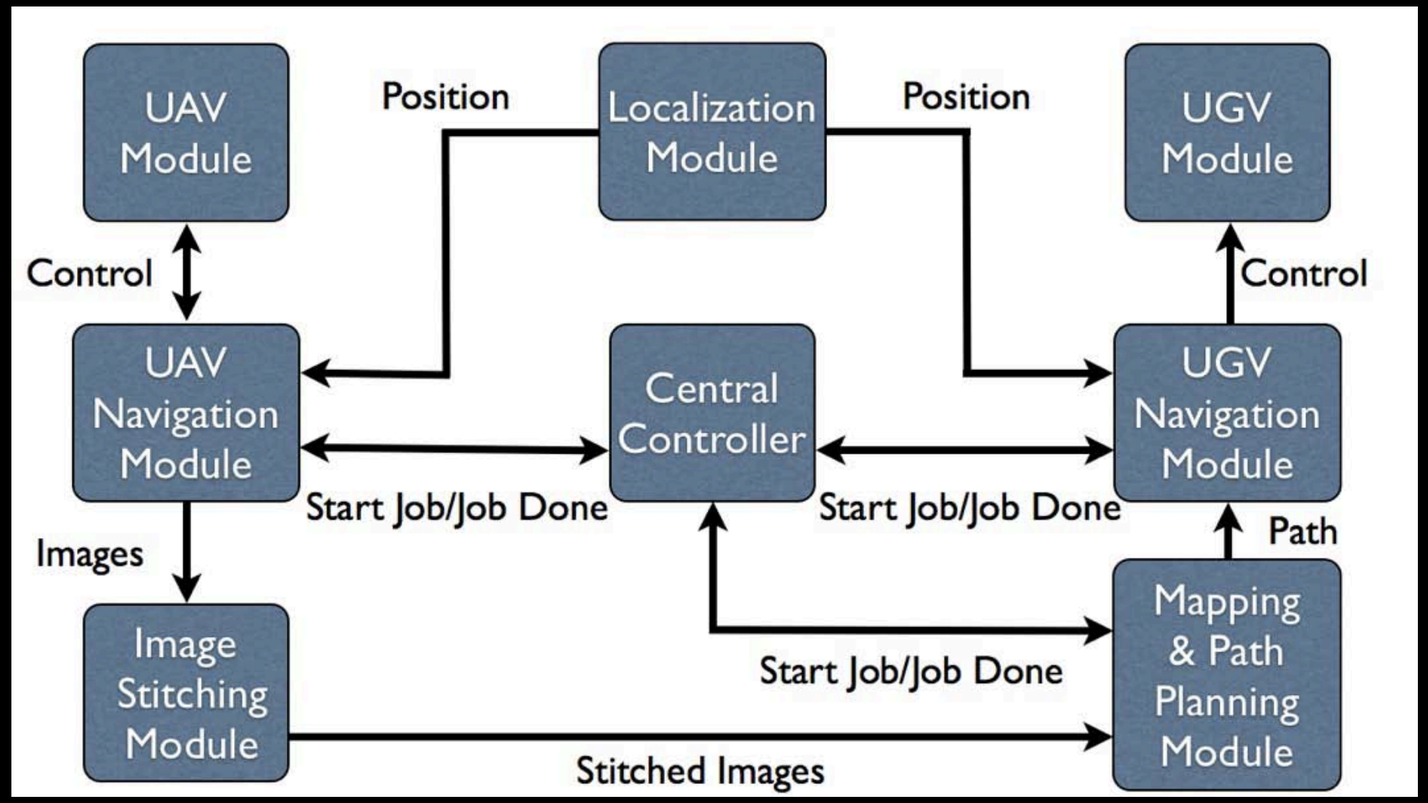
Parrot Ar.Drone Quadcopter

Adept MobileRobots Pioneer 3-DX

Software of the system

- UAV Navigation Module
- UGV Navigation Module
- Image Stitching Module
- Mapping & Path Planning Module
- Central Controller

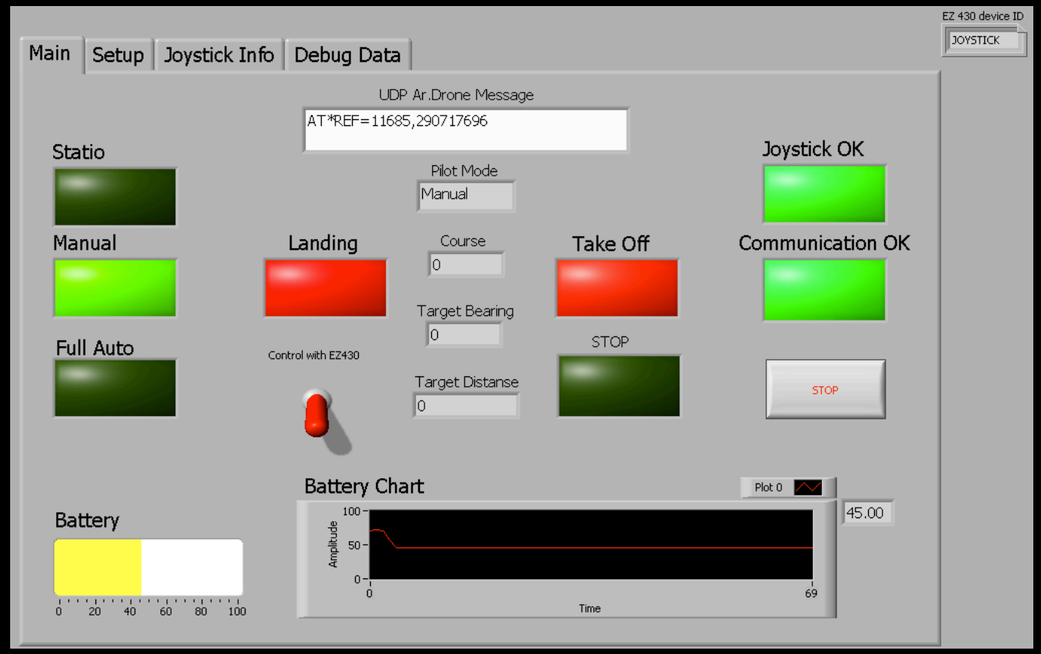
Modular System Architecture



UAV Navigation Module

The UAV navigation and data collection algorithm was implemented in the LabView environment. This application controls the Pitch, Roll, Yaw, and Attitude of the UAV, and receives telemetry as well as video from the UAV in real time.

User Interface



UAV Navigation Module

The controllers that were used are minimizing position, direction, and altitude errors, are of PID type, and were tuned using the Ziegler-Nichols method. If the UAV is within an accuracy radius of 1.5cm then it remains there for approximately 5 second, in order to be further stabilized and so that the camera views the ground from a parallel plane.

Feedback from the motion capture cameras

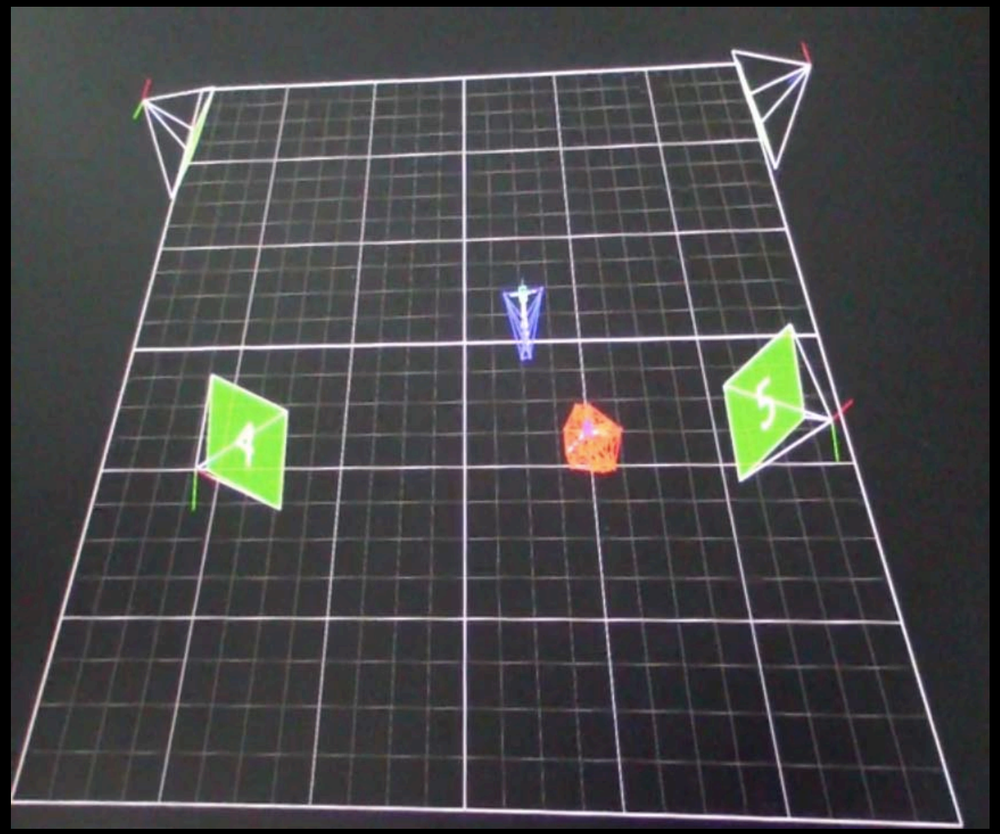


Image Stitching Module

In this project, one of the most important tasks was to be able to create a clear map of the explored area using aerial photos taken from the UAV. In order to create a map of the unknown environment, it requires sufficient number of photos of the area so that different images can be stitched together to create a bigger image of the explored area.

Images from the UAV

Image Stitching Module

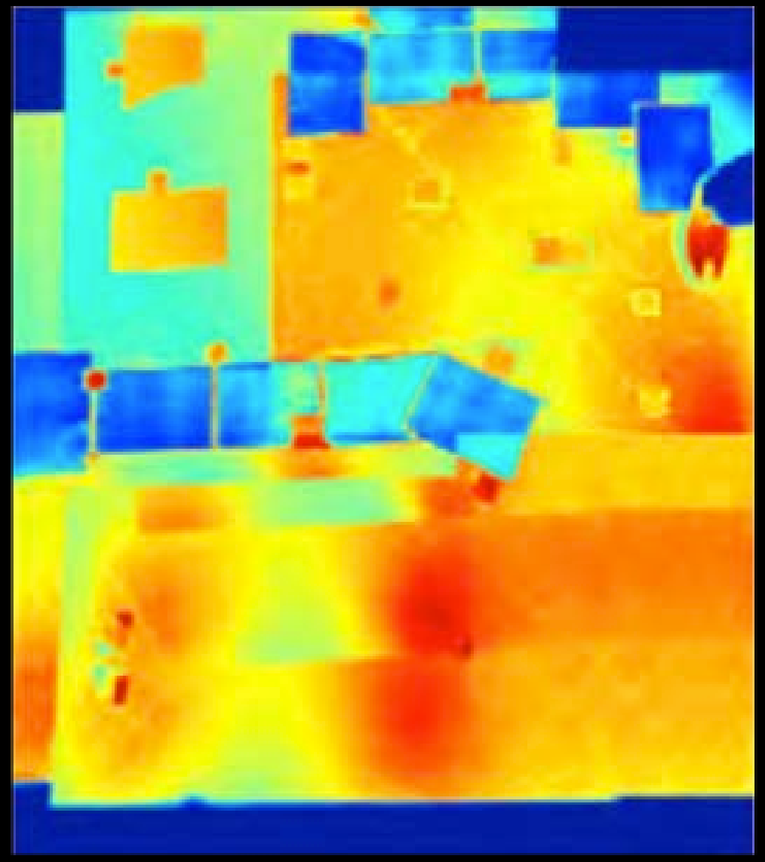
To stitch images, Scale-invariant feature transform algorithm which is also known as SIFT has been used which is one of the most widely used algorithm in computer vision to detect and extract key points in images. First, two images which overlap each other are taken and SIFT algorithm is applied on each image to extract key points in the images.

Key points example

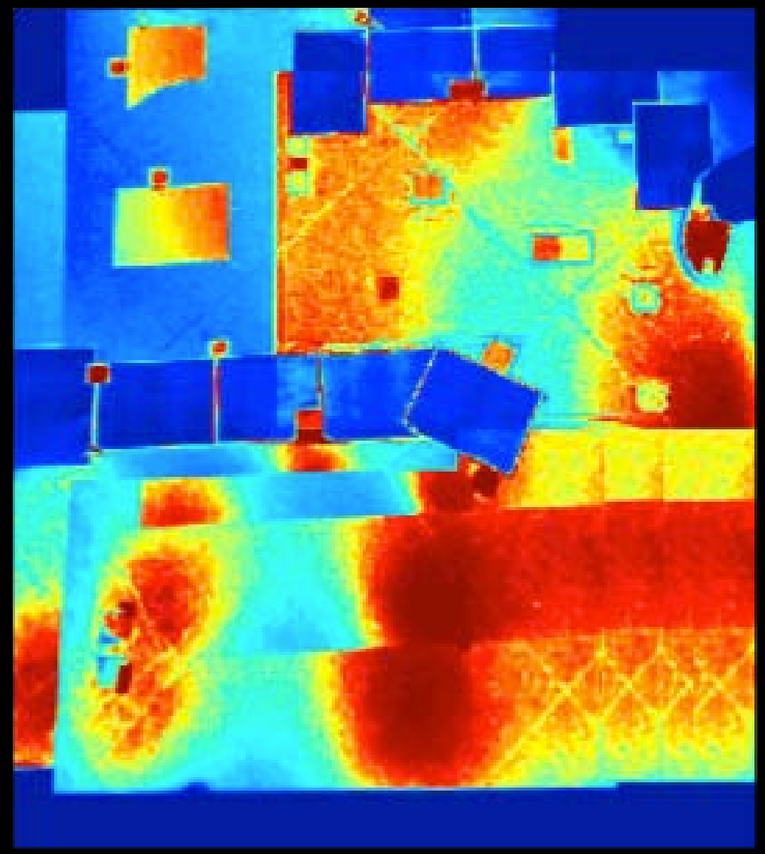
Stitched image

Mapping & Path Planning Module

Initial stitched image

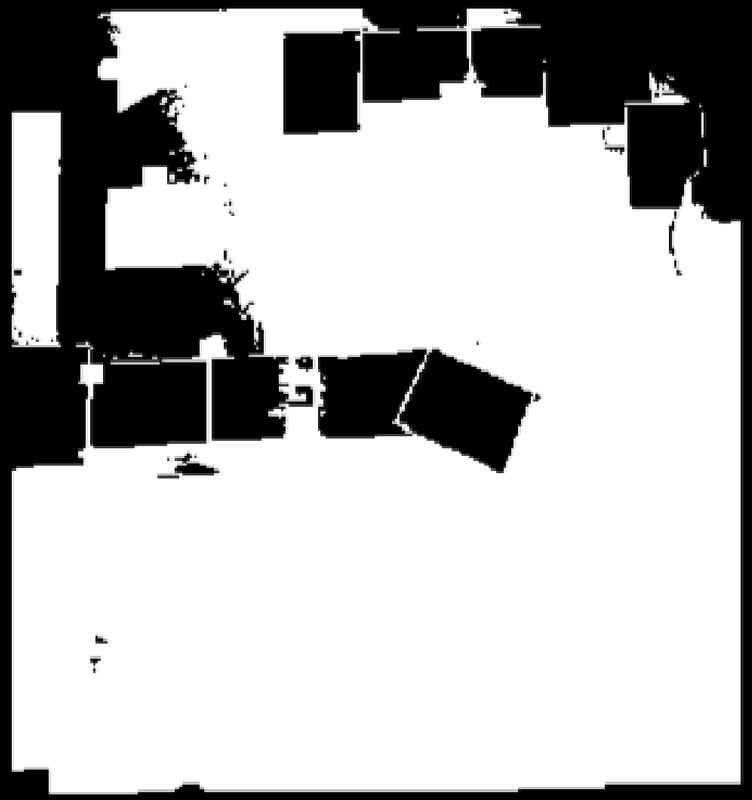


Value (HSV colorspace)



Value equalized

Mapping & Path Planning Module



Map binarization

Closing and cropping operations

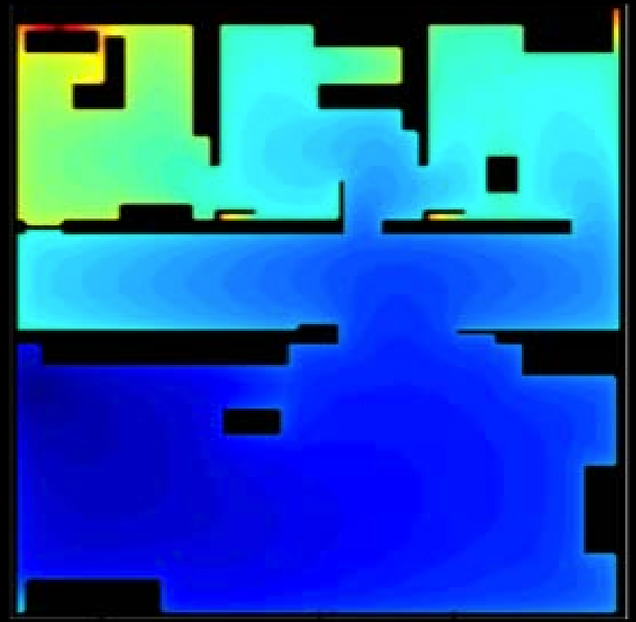
Mapping & Path Planning Module

Fast Marching Square (FM^2) Path Planning Method

FM^2 uses the principle of **light traveling** through different refraction indexes

Initial binary map

Map of velocities obtained with Fast Marching Method

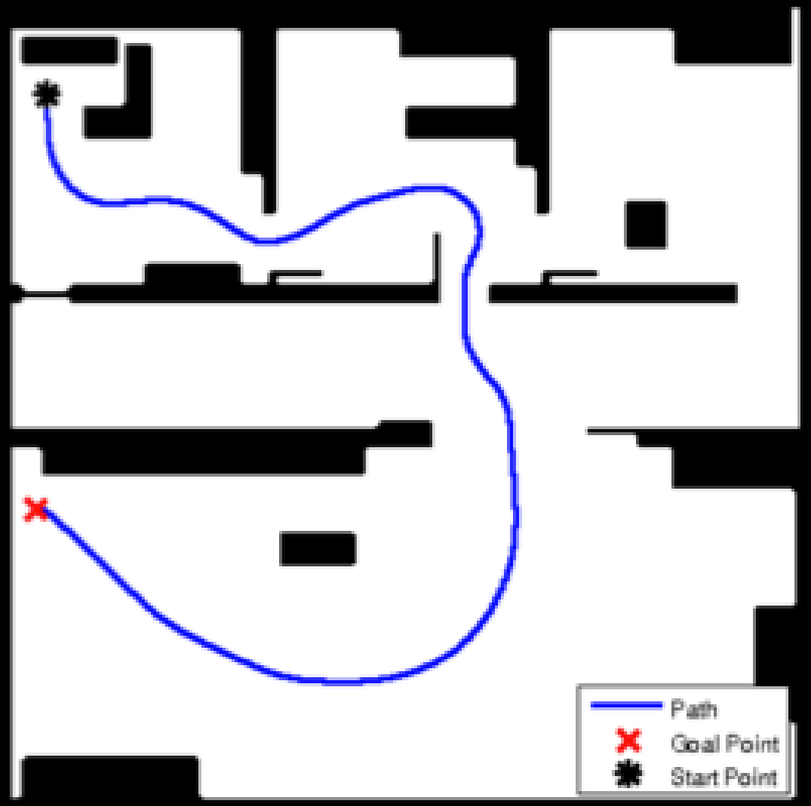


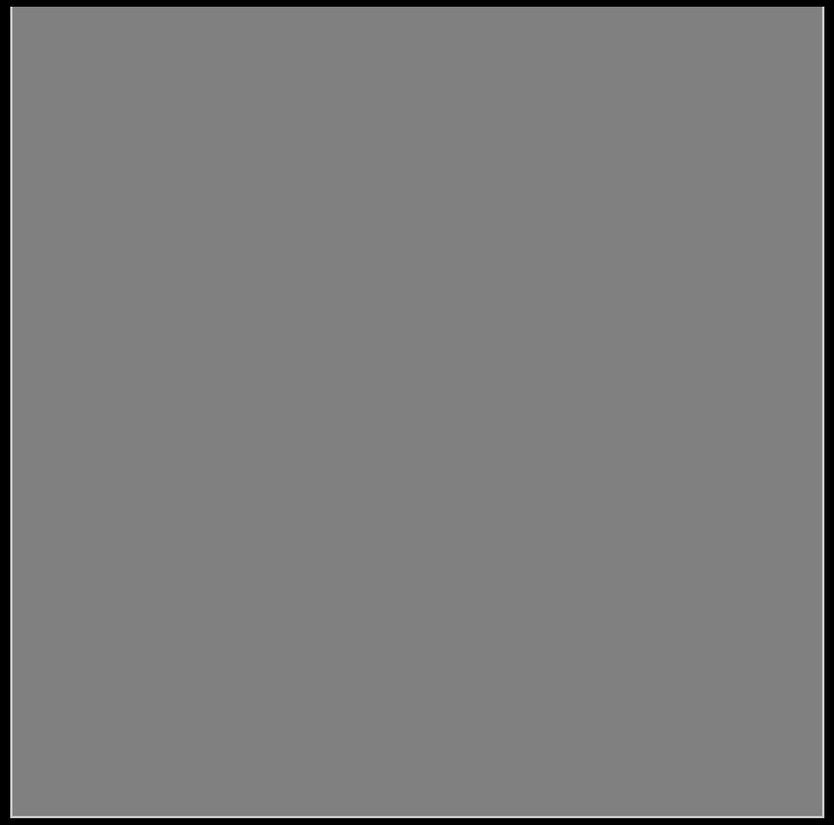
Wave propagation computed with Fast Marching Method

Mapping & Path Planning Module

Fast Marching Square (FM^2) Path Planning Method

FM^2 uses the principle of **light traveling** through different refraction indexes

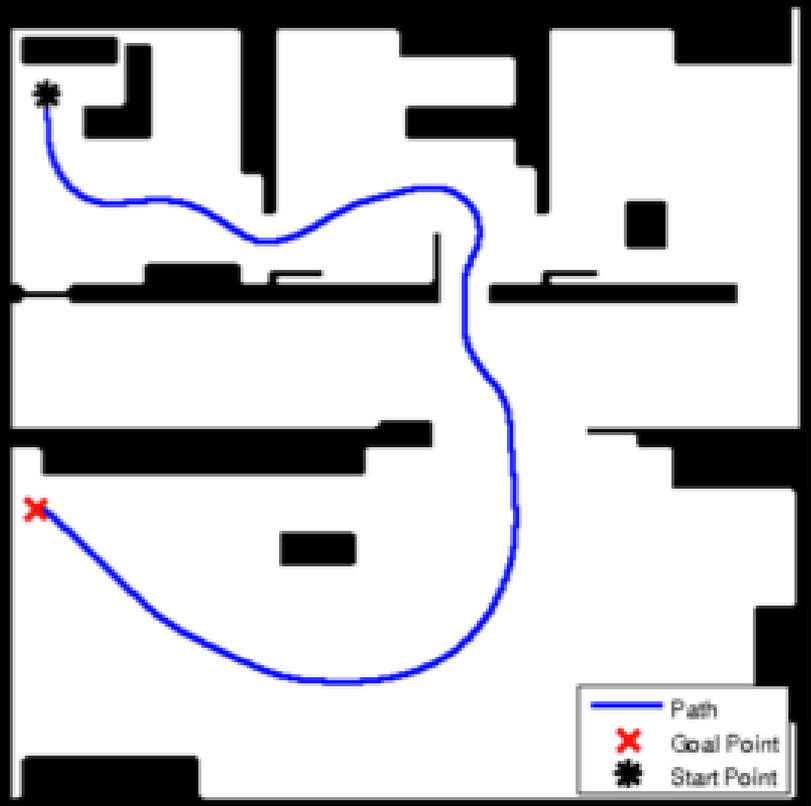


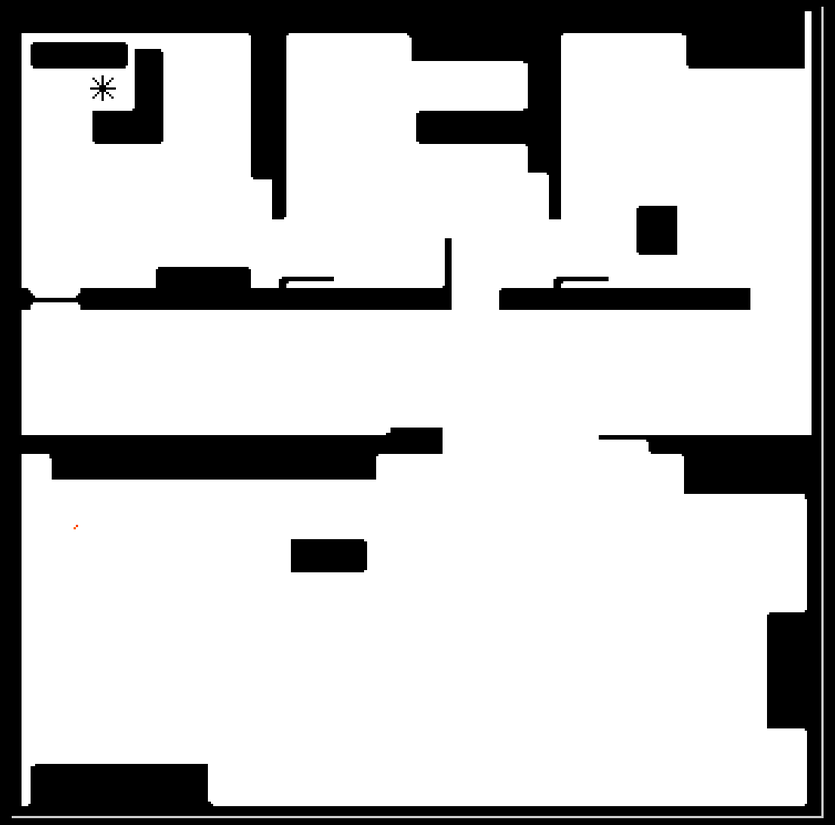


Mapping & Path Planning Module

Fast Marching Square (FM^2) Path Planning Method

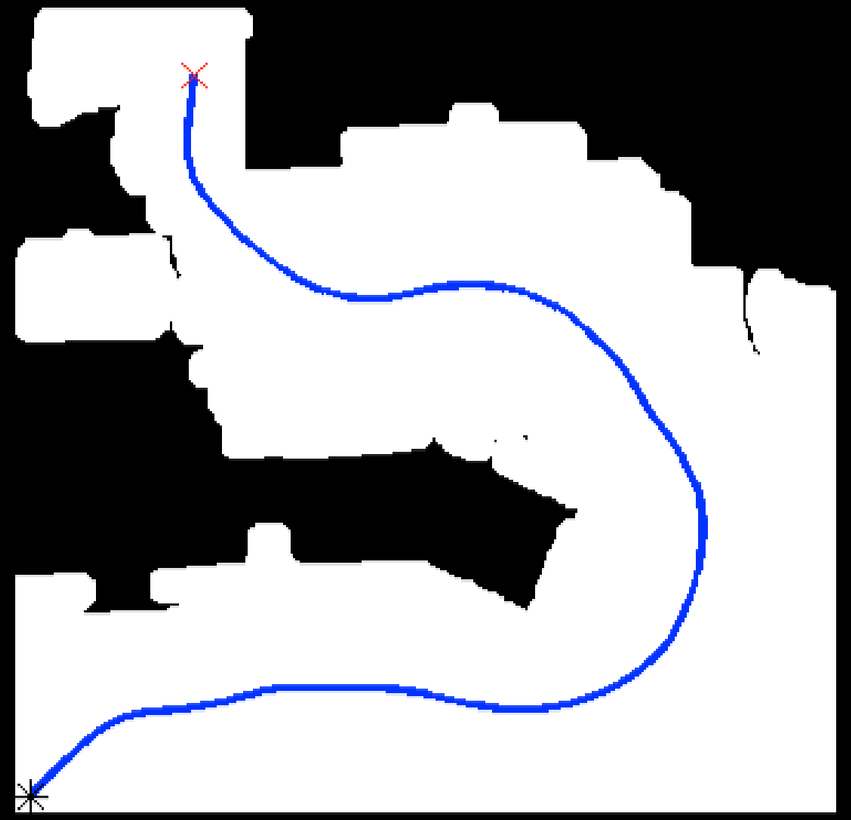
FM^2 uses the principle of **light traveling** through different refraction indexes





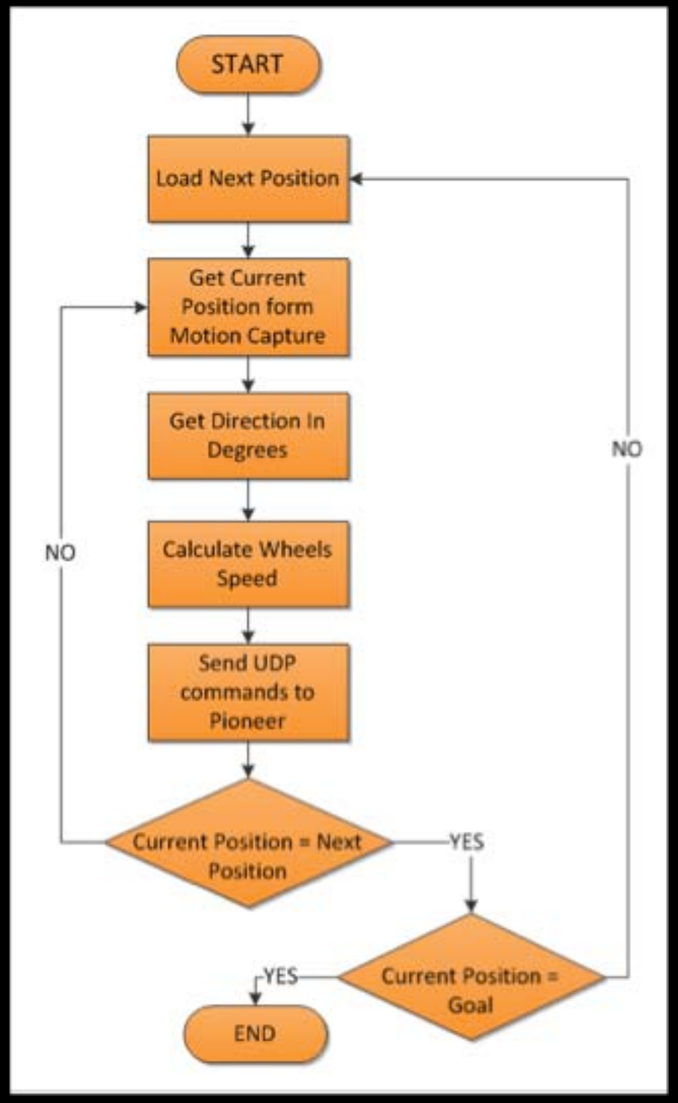
Mapping & Path Planning Module

Application to our map



Mapping & Path Planning Module

Once the path is computed, the robot should follow it. For that, the position and orientation of the robot is calculated with the motion capture system. The path is trimmed into many landmarks and the velocities of the wheels are set up in order to get to these landmarks. Thanks to the smoothness of the path, a P-like controller is enough to follow control the robot.



The result ...

http://www.youtube.com/watch?v=RqdwuKcUPfU

http://www.sse.gr/drastiriotita2_en.php?id=104

Thank you...

Questions ?

For more information please contact us at: giakoumidis@nyu.edu